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EPA United States Environmental Protection Agency

Technology Transfer Network - Air Toxics Web Site

Chromium Compounds

Hazard Summary-Created in April 1992; Revised in January 2000

Chromium occurs in the environment primarily in two valence states, trivalent chromium (Cr III) and hexavalent chromium (Cr VI). Exposure may occur from natural or industrial sources of chromium. Chromium III is much less toxic than chromium (VI). The respiratory tract is also the major target organ for chromium (III) toxicity, similar to chromium (VI). Chromium (III) is an essential element in humans. The body can detoxify some amount of chromium (VI) to chromium (III).
The respiratory tract is the major target organ for chromium (VI) toxicity, for acute (short-term) and chronic (long-term) inhalation exposures. Shortness of breath, coughing, and wheezing were reported from a case of acute exposure to chromium (VI), while perforations and ulcerations of the septum, bronchitis, decreased pulmonary function, pneumonia, and other respiratory effects have been noted from chronic exposure. Human studies have clearly established that inhaled chromium (VI) is a human carcinogen, resulting in an increased risk of lung cancer. Animal studies have shown chromium (VI) to cause lung tumors via inhalation exposure.

Please Note: The main sources of information for this fact sheet are EPA's Integrated Risk Information System (IRIS), which contains information on inhalation chronic toxicity and the RfC and oral chronic toxicity and the RfD, and the carcinogenic effects of chromium including the unit cancer risk for inhalation exposure, EPA's *Toxicological Review of Trivalent Chromium* and *Toxicological Review of Hexavalent Chromium*, and the Agency for Toxic Substances and Disease Registry's (ATSDR's) *Toxicological Profile for Chromium*.

Uses

- The metal chromium is used mainly for making steel and other alloys. (1)
- Chromium compounds, in either the chromium (III) or chromium (VI) forms, are used for chrome plating, the manufacture of dyes and pigments, leather and wood preservation, and treatment of cooling tower water. Smaller amounts are used in drilling muds, textiles, and toner for copying machines. (1)

Sources and Potential Exposure

- Chromium is a naturally occurring element in rocks, animals, plants, soil, and volcanic dust and gases. (1)
- Chromium occurs in the environment predominantly in one of two valence states: trivalent chromium (Cr III), which occurs naturally and is an essential nutrient, and hexavalent chromium (Cr VI), which, along with the less common metallic chromium (Cr 0), is most commonly produced by industrial processes. (1)
- Chromium (III) is essential to normal glucose, protein, and fat metabolism and is thus an essential dietary element. The body has several systems for reducing chromium (VI) to chromium (III). This chromium (VI) detoxification leads to increased levels of chromium (III). (1)
- Air emissions of chromium are predominantly of trivalent chromium, and in the form of small particles or aerosols. (1,2)
- The most important industrial sources of chromium in the atmosphere are those related to ferrochrome production. Ore refining, chemical and refractory processing, cement-producing plants, automobile brake lining and catalytic converters for automobiles, leather tanneries, and chrome pigments also contribute to the atmospheric burden of chromium. (3)
- The general population is exposed to chromium (generally chromium [III]) by eating food, drinking water, and inhaling air that contains the chemical. The average daily intake from air, water, and food is estimated to be less than 0.2 to 0.4 micrograms (µg), 2.0 µg, and 60 µg, respectively. (1)
- Dermal exposure to chromium may occur during the use of consumer products that contain chromium, such as wood treated with copper dichromate or leather tanned with chromic sulfate. (1)
- Occupational exposure to chromium occurs from chromate production, stainless-steel production, chrome plating, and working in tanning industries; occupational exposure can be two orders of magnitude higher than exposure to the general population. (1)
- People who live in the vicinity of chromium waste disposal sites or chromium manufacturing and processing plants have a greater probability of elevated chromium exposure than the general population. These exposures are generally to mixed chromium (VI) and chromium (III). (1)

Assessing Personal Exposure

- Laboratory tests can detect chromium in the blood, urine, and hair of exposed individuals. (1,5)
- In many cases analysis is done for total chromium because it is difficult to differentiate between chromium VI and chromium III in tests. (1)

Health Hazard Information

Acute Effects:

Chromium VI

- Chromium (VI) is much more toxic than chromium (III), for both acute and chronic exposures. (1,3,4)
- The respiratory tract is the major target organ for chromium (VI) following inhalation exposure in humans. Shortness of breath, coughing, and wheezing were reported in cases where an individual inhaled very high concentrations of chromium trioxide. (1,4)
- Other effects noted from acute inhalation exposure to very high concentrations of chromium (VI) include gastrointestinal and neurological effects, while dermal exposure causes skin burns in humans. (1,4,5)
- Ingestion of high amounts of chromium (VI) causes gastrointestinal effects in humans and animals, including abdominal pain, vomiting, and hemorrhage. (1)
- Acute animal tests have shown chromium (VI) to have extreme toxicity from inhalation and oral exposure. (1,6)

Chromium III

- Chromium (III) is an essential element in humans, with a daily intake of 50 to 200 µg/d recommended for adults. (1)
- Acute animal tests have shown chromium (III) to have moderate toxicity from oral exposure. (1,6)

Chronic Effects (Noncancer)

Chromium VI

- Chronic inhalation exposure to chromium (VI) in humans results in effects on the respiratory tract, with perforations and ulcerations of the septum, bronchitis, decreased pulmonary function, pneumonia, asthma, and nasal itching and soreness reported. (1,4,5)
- Chronic human exposure to high levels of chromium (VI) by inhalation or oral exposure may produce effects on the liver, kidney, gastrointestinal and immune systems, and possibly the blood. (1,4,5)
- Rat studies have shown that, following inhalation exposure, the lung and kidney have the highest tissue levels of chromium. (1,4,5)
- Dermal exposure to chromium (VI) may cause contact dermatitis, sensitivity, and ulceration of the skin. (1,4,5)
- The Reference Concentration (RfC) for chromium (VI) (particulates) is 0.0001 mg/m^3 based on respiratory effects in rats. The RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious noncancer effects during a lifetime. It is not a direct estimator of risk but rather a reference point to gauge the potential effects. At exposures increasingly greater than the RfC, the potential for adverse health effects increases. Lifetime exposure above the RfC does not imply that an adverse health effect would necessarily occur. (7)
- EPA has medium confidence in the RfC for chromium VI (particulates) based on medium confidence in the study on which it was based because of uncertainties regarding upper respiratory tract, reproductive, and renal effects resulting from the exposures. (7)
- The Reference Concentration (RfC) for chromium (VI) (chromic acid mists and dissolved Cr (VI) aerosols) is 0.000008 mg/m^3 based on respiratory effects in humans. (7)
- EPA has low confidence in the RfC based on low confidence in the study on which the RfC for chromium (VI) (chromic acid mists and dissolved Cr (VI) aerosols) is based. This is because of (1) the uncertainties regarding the exposure characterization and the role of direct contact for the critical effect; and (2) low confidence in the supporting studies which are equally uncertain regarding the exposure characterization. (7)
- The Reference Dose (RfD) for chromium (VI) is 0.003 mg/kg/d based on the exposure at which no effects were noted in rats exposed to chromium in the drinking water. (7)
- EPA has low confidence in the RfD based on: low confidence in the study on which the RfD for chromium (VI) was based because a small number of animals were tested, a small number of parameters were measured, and no toxic effects were noted at the highest dose tested; and low confidence in the database because the supporting studies are of equally low quality and developmental endpoints are not well studied. (7)

Chromium III

- Although data from animal studies have identified the respiratory tract as the major target organ for chronic chromium exposure, these data do not demonstrate that the effects observed following inhalation of chromium (VI) particulates are relevant to inhalation of chromium (III). (8)
- EPA has not established an RfC for chromium (III). (8)
- The RfD for chromium (III) is 1.5 mg/kg/d based on the exposure level at which no effects were observed in rats exposed to chromium (III) in the diet. (8)
- EPA has low confidence in the RfD based on: low confidence in the study on which the RfD for chromium (III) was based due to the lack of explicit detail on study protocol and results; and low confidence in the database due to the lack of high-dose supporting data. (8)

Reproductive/Developmental Effects:

Chromium VI

- Limited information on the reproductive effects of chromium (VI) in humans exposed by inhalation suggest that exposure to chromium (VI) may result in complications during pregnancy and childbirth. (1)
- Animal studies have not reported reproductive or developmental effects from inhalation exposure to chromium (VI). Oral studies have reported severe developmental effects in mice such as gross abnormalities and reproductive effects including decreased litter size, reduced sperm count, and degeneration of the outer cellular layer of the seminiferous tubules. (1,4)

Chromium III

- No information is available on the reproductive or developmental effects of chromium (III) in humans. (3)
- A study of mice fed high levels of chromium (III) in their drinking water has suggested a potential for reproductive effects, although various study characteristics preclude a definitive finding. (3)
- No developmental effects were reported in the offspring of rats fed chromium (III) during their developmental period. (1,3)

Cancer Risk:

Chromium VI

- Epidemiological studies of workers have clearly established that inhaled chromium is a human carcinogen, resulting in an increased risk of lung cancer. Although chromium-exposed workers were exposed to both chromium (III) and chromium (VI) compounds, only chromium (VI) has been found to be carcinogenic in animal studies, so EPA has concluded that only chromium (VI) should be classified as a human carcinogen. (1,7)
- Animal studies have shown chromium (VI) to cause lung tumors via inhalation exposure. (1,5)
- EPA has classified chromium (VI) as a Group A, known human carcinogen by the inhalation route of exposure. (7)
- EPA used a mathematical model, based on data from an occupational study of chromate production workers, to estimate the probability of a person developing cancer from continuously breathing air containing a specified concentration of chromium. EPA calculated an inhalation unit risk estimate of 1.2×10^{-2} $(\mu g/m^3)^{-1}$. EPA estimates that, if an individual were to continuously breathe air containing chromium at an average of 0.00008 µg/m^3 (8×10^{-8} mg/m^3) over his or her entire lifetime, that person would theoretically have no more than a one-in-a-million increased risk of developing cancer. Similarly, EPA estimates that continuously breathing air containing 0.0008 µg/m^3 (8×10^{-7} mg/m^3) would result in not greater than a one-in-a-hundred thousand increased risk of developing cancer during one's lifetime, and air containing 0.008 µg/m^3 (8×10^{-6} mg/m^3) would result in not greater than a one-in-ten-thousand increased risk of developing cancer during one's lifetime. For a detailed discussion of confidence in the potency estimates, please see IRIS. (7)

Chromium III

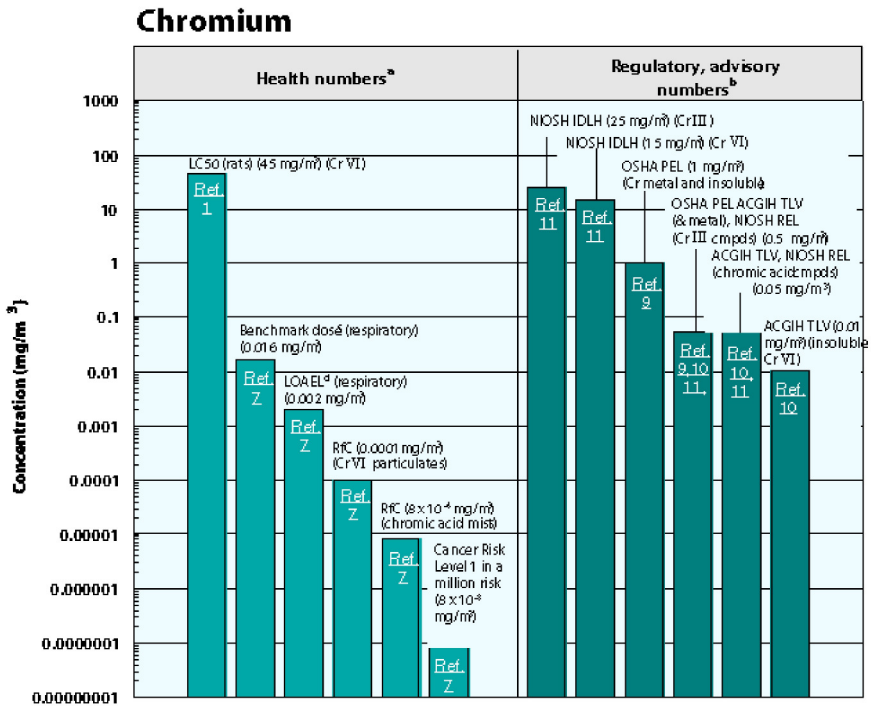
- No data are available on the carcinogenic potential of chromium (III) compounds alone. (1,8)
- EPA has classified chromium (III) as a Group D, not classifiable as to carcinogenicity in humans. (8)
- EPA has stated that "the classification of chromium (VI) as a known human carcinogen raises a concern for the carcinogenic potential of chromium (III)". (8)

Physical Properties

- The metal, chromium (Cr), is a steel-gray solid with a high melting point and an atomic weight of 51.996 g/mol. Chromium has oxidation states ranging from chromium (-II) to chromium (+VI). (1)
- Chromium forms a large number of compounds, in both the chromium (III) and the chromium (VI) forms. Chromium compounds are stable in the trivalent state, with the hexavalent form being the second most stable state. (1)
- The chromium (III) compounds are sparingly soluble in water and may be found in water bodies as soluble chromium (III) complexes, while the chromium (VI) compounds are readily soluble in water. (1)

Conversion Factors (only for the gaseous form):
To convert concentrations in air (at 25°C) from ppm to mg/m^3: mg/m^3 = (ppm) × (molecular weight of the compound)/(24.45). For chromium: 1 ppm = 2.12 mg/m^3. To convert concentrations in air from µg/m^3 to mg/m^3: mg/m^3 = (µg/m^3) × (1 mg/1,000 µg).

Health Data from Inhalation Exposure



ACGIH TLV--American Conference of Governmental and Industrial Hygienists' threshold limit value expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effects.
LC$_{50}$ (Lethal Concentration$_{50}$)--A calculated concentration of a chemical in air to which exposure for a specific length of time is expected to cause death in 50% of a defined experimental animal population.
NIOSH IDLH -- National Institute of Occupational Safety and Health's immediately dangerous to life or health concentration; NIOSH recommended exposure limit to ensure that a worker can escape from an exposure condition that is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from the environment.
NIOSH REL--NIOSH's recommended exposure limit; NIOSH-recommended exposure limit for an 8- or 10-h time-weighted-average exposure and/or ceiling.
OSHA PEL--Occupational Safety and Health Administration's permissible exposure limit expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effect averaged over a normal 8-h workday or a 40-h workweek.

The health and regulatory values cited in this factsheet were obtained in December 1999.
[a]Health numbers are toxicological numbers from animal testing or risk assessment values developed by EPA.
[b]Regulatory numbers are values that have been incorporated in Government regulations, while advisory numbers are nonregulatory values provided by the Government or other groups as advice. OSHA numbers are regulatory, whereas NIOSH and ACGIH numbers are advisory.
[c]The benchmark dose is from the critical study used as the basis for the EPA's RfC for Cr(VI) particulates.
[d]The LOAEL is from the critical study used as the basis for the EPA's RfC for chromic acid mists and dissolved Cr (VI) aerosols.

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